Data Logging in a Motor Vehicle

5   The invention relates to a method of logging messages
sent over a data bus in a motor vehicle between
electronic units. Selected critical messages may be
temporarily stored and later, at a suitable point in
time, transferred into a data processing device
10 externally of the motor vehicle, where such critical
messages may be analyzed in more detail.

German Offenlegungsschrift DE 101 21 061 A1 discloses a
monitoring apparatus and a monitoring system for a data
15 bus which is provided in a motor vehicle and on which
messages are sent between electronic units. Several
electronic units are connected to the data bus by a bus
interface, and the communication network in the motor
vehicle has a data interface, by means of which an error
20 memory may be read into a data processing device
externally of the motor vehicle. As a difference from the
presently claimed invention, however, in the monitoring
method according to the DE 101 21 061 A1, the messages on
the bus are verified directly by a monitoring unit
25 without temporary storage. The verification is performed
with a list which is stored in a memory of the monitoring
unit and in which all the permitted messages occurring on
the bus are enumerated. In case on the bus a message
appears which is not present in such a list, then such a
30 foreign message is submitted to an evaluation, and an
evaluating unit signals an endangering potential which
may emerge from the foreign message. In case the thus

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determined endangering potential exceeds a previously
given threshold value, an error signal is entered into an
error memory. Such a known monitoring system serves for
recognizing, whether all connected bus participants also

5   have a corresponding access privilege to the bus. This
may cause a problem in motor vehicles if control devices
are subsequently installed without a corresponding
clearance being available from the vehicle manufacturer
for such control devices. In such a case a control device

10   not cleared for installation could not be immediately
recognized by the monitoring apparatus according to the
DE 101 21 061 A1.

German Patent Application DE 100 46 832 A1 describes an

15   apparatus and a method for detecting travel data of a
motor vehicle. The travel data are logged in an accident
recorder. The latter consists essentially of a memory
device which is a continuous memory and whose memory
contents are cyclically overwritten. In this manner the

20   recorded data are always preserved for a predetermined
time period before they are continuously overwritten by
the actual data upon lapse of the predetermined time
period. The travel data are directly stored in the
accident recorder. A bus monitoring or an analysis of bus

25   messages is not provided, nor is a readout of the
accident recorder during normal operation of the motor
vehicle.

Possibilities of a bus access during the operational

30   period of a motor vehicle are known from the vehicle
management system in German Offenlegungsschrift DE 101 43
556 A1. The control devices in the motor vehicle may be

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accessed by an air interface, and a telematic-CAN-data bus as well as by a CAN-gateway. The access itself is tied to an access privilege. A monitoring of the bus traffic concerning error events or error messages is not

5   performed.

Bus messages are not logged in any of the above-discussed processes. It is therefore not possible with any of the known methods or with any combination thereof to more

10   closely analyze an error-encumbered bus traffic. This is achieved only by the invention.

The inventors were therefore faced with the object to develop, for further advancement and for the elimination

15   of errors in the existing software of control devices in a motor vehicle, a data capture which assists in tracking down such software errors.

This object is achieved with a method according to the

20   features of claim 1. Advantageous aspects of the method according to the invention are contained in the dependent claims and in the description of the embodiments.

The solution succeeds in particular by logging messages

25   on the data bus and temporarily storing the sent messages in a cyclically overwritable, volatile memory. The messages stored temporarily in this manner may be examined in a targeted manner for the attributes of interest by means of a verification program. By means of

30   definable triggering events which, for example, may be formed from individual or several attributes of the messages, a storing of the temporarily stored messages in

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a non-volatile second memory means may be initiated. For
this purpose, the occurrence of the defined triggering
event is ascertained by a monitoring unit, and the data
content of the volatile memory means is subsequently
5   transferred into the memory cells of the non-volatile
memory means.

The advantage principally achieved with the above process
resides in the possibility of backtracking the bus
10   traffic. The exchanged messages may be backtracked and
thus provide for the possibility to ascertain which
process and which control device sent the error message
onto the bus. This decisively aids in the error-seeking
in complex communication networks. By means of the
15   backtracking the error message or by means of an analysis
as to which message has eventually triggered an error in
the communications network, it may be ascertained as to
which process is responsible for the error and which
program step has triggered it. The error-seeking in the
20   software programming of combinations of complex control
devices is decisively facilitated in this manner.

According to an advantageous embodiment of the method,
the definable trigger event may be exchanged over a data
25   interface of the communications network. By means of the
trigger event, the error-seeking may be controlled in a
targeted manner, and only the occurrence of certain error
events is logged in the non-volatile storing means. Since
the trigger event decisively determines which message can
30   be evaluated as an error message, by means of a suitable
definition of the trigger event and by means of its

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exchangeability, a flexible and targeted error-seeking
may be established in the communications network.

According to another advantageous embodiment of the
method, by means of parameterizable attributes which may
be exchanged over a data interface of the communications
network, it may be established which messages on the bus
are to be logged and temporarily stored in the storing
means. In case of a CAN-bus system, such parameterizable
attributes may be, for example, the so-called CAN-
identifiers which may be sent to the monitoring unit as a
parameter list. The monitoring unit then will temporarily
store only those messages on the CAN-bus, whose
identifier is contained in the parameter list. Further
possibilities for the parameterizable attributes are
selected error codes which are contained in the CAN-
communication or selected bits within the CAN-
communication whose fold-down indicates an error. This
has the advantage that not all messages present on the
bus need to be logged in the temporary memory, and that
the analysis of the temporarily stored messages is
limited to the previously selected messages.

According to a further advantageous embodiment of the
method, the non-volatile memory is read into an external
electronic data processing device outside the motor
vehicle. In such an external data processing device a
more accurate analysis of the logged messages may be
performed with a diagnostic program. Preferably, the data
interface for reading the non-volatile memory may be a
so-called air interface. As an air interface there is
meant a wireless-based transfer by a mobile radio or by a

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telematic CAN bus or by other wireless-based data. The
reading of the non-volatile memory is triggered by the
external data processing device. In this arrangement the
advantage of logging error messages in a non-volatile

5   storing medium in the motor vehicle proper manifests
itself. Namely, in this manner error messages do not
become lost once they occur and they may be analyzed in
more detail in principle at a later, arbitrarily chosen
time. For its removal, the error does not have to occur

10   exactly when a qualified servicing engineer is on site at
the motor vehicle.

In the description which follows, an embodiment will be
set forth in more detail in conjunction with the drawing,

15   where

Figure 1   is a schematic overview showing the most
           important functions of the invention,
Figure 2   is a diagram showing the layout of a main
20   program as it may be used in conjunction with
           the invention and
Figure 3   is a simplified illustration of the structure
           of a CAN-communication.

25   Figure 1 schematically shows the integrated power train
of a motor vehicle. The principal functions are combined
in a power train controller (PTC). The power train
controller integrates the transmission control apparatus,
the engine control apparatus as well as the clutch

30   control apparatus. Therefore, the power train controller
is coupled with the transmission 1, the clutch 2 and the
engine 3. Further control devices which are important for

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the operation of the motor vehicle are decentralized. As examples the brake control device 4 and the steering control device 5 are shown. To ensure the highest possible safety against a failure of the control devices

5   and to thus make possible a road-worthiness, the above-noted control devices are redundantly present, since they contain safety-related functions. The control devices proper communicate among one another over a data bus and therefore all have a communication connection with the

10   data bus 6. The data bus is formed preferably as a CAN (Controlled Area Network) bus system. Further, a transfer system 7 is connected to the CAN bus. The transfer system comprises a CAN bus interface 8 which is preferably embedded into a freely programmable processor 9. By means

15   of the transfer system 7 a bi-directional data transfer is effected out of the vehicle and into the control devices thereof. The transfer system therefore further integrates an RS 232 interface, over which, for example, a wireless modem 10 may be integrated into the transfer

20   system 7. Further attributes of the transfer system 7 are a first volatile RAM memory 11 (Read and Access Memory) and a second non-volatile memory 12 which is preferably a so-called flash. Both storing media may be integrated into the controller or, as illustrated in Figure 1, may

25   be accessed by the controller 9 over a serial interface. By means of the wireless modem 10, communication may be established with an external, further wireless modem 13 over established mobile wireless standards, such as GSM, SMS or GPRS. The external wireless modem 13 is connected

30   to an external data processing device 14. Further transfer methods considered for the wireless connection are: the Bluetooth standard, the IEEE802.11 WLAN standard

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and the UMTS-IMT-2000 standard. Less considered for the
wireless transfer process are, for example, the DECT
standard, the ISM band or the Hyperlan2 standard.

5   By means of such a transfer system 7 located in the
vehicle, for example, a remote diagnostic system,
implemented in the external data processing device 14, is
in a position to act upon the power train controller PTC
and upon the other control devices connected to the CAN
10   bus in the vehicle and to thus also affect the vehicle to
be monitored.

The principal task of the transfer apparatus is, however,
the logging of messages which are exchanged on the data
15   bus between the control devices in the vehicle. For this
purpose, the controller 9 has its own processor in which
an executable program is implemented. The process is
performed by means of the executable program and the
apparatus attributes of the transfer apparatus 7 as
20   defined in the claims. All the messages on the data bus -
preferably a CAN bus - are logged over a bus interface 8,
preferably a CAN bus interface. All logged messages are
temporarily stored in a first volatile storing medium 11.
The volatile storing medium 11 may be a RAM. To save
25   storage capacity, the memory is a so-called ring memory,
that is, the memory registers are, starting with the
first memory register, successively fully written, until
the last memory register n is also occupied. Thereafter
the already stored bus messages are cyclically
30   overwritten by the newly incoming bus messages, again
starting with the first memory register. A second
principal task of the executable program is the analysis

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of the read bus messages. Such an analysis may be performed to a certain extent online while the bus messages on the bus are being read, or the analysis of the bus messages occurs while they are temporarily stored in the first volatile storing medium. The second alternative of temporary storing has the advantage that more time is available for the analysis. The analysis of the bus messages may extend to the transmitter and data of the messages as well as to the useful contents of the message. By means of the executable program the read message or the temporarily stored message is examined for certain attributes which are presented to the program as an attribute list. The attribute list may be parameterizable, by which it is meant that the individual attributes may be exchanged as parameters as required and according to the purpose of examination. Such an exchange may be performed by the external data processing device 14 over the wireless interface as a download process in which a new actualized attribute list 15 is inputted in an accessible storing medium in the transfer apparatus 7. In the embodiment according to Figure 1 as attributes which can be monitored, the identifiers of the CAN communications: CAN ID L1, CAN ID L2, ... CAN ID Lm are exemplarily named. More detailed discussion is given in the description of Figure 3.

If the executable program in the read or simultaneously stored bus messages ascertains the presence of an attribute to be monitored, the cyclic overwriting of the volatile storing medium 11 is stopped by the newly incoming bus messages, and the memory content of the volatile storing medium 11 is transferred

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to a second non-volatile storing medium 12 which is
preferably a flash memory. Upon conclusion of the
transfer process, the cyclic overwriting of the first
volatile storing medium 11 may resume. As soon as a
storing step occurred in the non-volatile storing medium
12, in a further process step a first message, preferably
as a mobile wireless message, is prepared which means
that on the data bus an event of interest has taken
place. The attributes to be monitored and transferred
with the attribute list 15 namely act as trigger events
to secure the data content of the first volatile storing
medium to ensure that it will be available for a later
query in a non-volatile storing medium. The trigger event
may consist of a single attribute of a message or of a
combination of various attributes which must occur
simultaneously or in a given sequence in order to define
a trigger event for the prescribed transfer process. The
prepared message is transferred preferably over a mobile
wireless connection to an external predetermined
terminal. Such a transfer process is repeated by the
executable program over the modem 10 as often until a
connection with the selected call number is in fact
established. To this end, one or more telephone numbers
are stored in the transfer apparatus 7 in a suitable
manner. By virtue of such a message, an external
operating person or user of the data processing device 14
is made aware of the fact that an event previously
defined as a trigger event has occurred on the data bus
of the vehicle to be monitored. Then the user of the data
processing device 14 may himself/herself decide, at which
point in time does he/she wish to read out the memory
content of the non-volatile storing medium 12 over the

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mobile wireless interface and to submit it to a more accurate analysis in the data processing device 14.

To proceed in such a manner has mainly two
5   advantages.

The securing of logged bus messages in a non-volatile storing medium and the read-out of the non-volatile storing medium as needed, permits a monitoring of the bus
10 traffic independently of whether or not a testing engineer is present. The logged bus traffic allows an analysis at a later point in time which means that the vehicle may continue to be operated, and that an external service station in the form of the data processing device
15 14 does not need to be continuously manned. By virtue of the fact that not only the trigger event itself was logged, but also, that the messages previously exchanged on the bus were logged according to the memory size of the volatile storing medium 11, it is feasible to analyze
20 not only the trigger event proper, but also the history which transpired before the occurrence of the trigger event on the communications network of the motor vehicle. This is very helpful particularly in error-seeking in the software programs of the control devices. By means of the
25 logging of the complete bus messages, a direct indication is given as to which process and thus which control device and which software have sent an error message to the bus. This is a very important information for the beginning of the error-seeking.
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The second advantage of the automated logging resides in that it is not necessary to have a service technician on

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site if occasionally a rarely occurring error appears.
Namely, a once-reported, rarely occurring error may be
defined as a trigger event and is then logged with the
transfer apparatus 7 in an automated manner and preserved
5   in a lasting permanent storing medium 12, so that even
rarely occurring errors may be tracked down.

According to an advantageous embodiment, the non-volatile
storing medium may have a larger storage capacity than
10   that of the volatile storing medium 11. This has the
advantage that the volatile storing medium 11, dependent
upon the size of the non-volatile storing medium 12, may
be read out in a multiple manner before the non-volatile
storing medium 12 must be reset. In this way several
15   trigger events may be advantageously logged and stored in
a non-volatile manner.

Figure 2 shows an exemplary application of the executable
program, with which the method according to the invention
20   is performed. The structure of the program may be
theoretically divided into five main components, namely,
the initialization, the reading of the bus messages, the
evaluation of the communications on the bus, the
acknowledgment to an external data processing device as
25   well as the termination of the monitoring process upon
turning off the motor vehicle.

The initialization serves for the preparation of the
transfer apparatus. Among others, the real-time clock and
30   the modem are started. Further, diverse variables and
objects are defined which are necessary for operating the
program. These are in particular the trigger events and

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the attributes or parameters which are to be separately
monitored. These parameters or trigger events may be
loaded into the processor from a storing medium or they
may be newly read over the mobile wireless interface and
5   newly defined by the external data processing device. The
second step is performed preferably over a flash process.

The bus messages are read during the second program part.
In this case there are read both the data on the data bus
10   of the vehicle, mostly on the CAN bus, and, if available,
SMS messages which have arrived over the modem 10. This
program step serves to render available the data of the
communication interface for the subsequent functions.

15   In the next program part which is "evaluate bus
communication", the bus communications on the data bus
and on the modem interface are read. The data on the data
bus are, as previously noted, cyclically logged in the
volatile storing medium 11, and the modem interface is
20   monitored for the presence of external messages. In case
external messages are present, they are read-in and
evaluated without delay. In case the external messages
contain commands, such commands have a priority in the
further processing and are executed with priority. Such
25   commands may pertain particularly to the read-out of the
non-volatile memory. A flash process can also be
performed, with which software programs are implemented
in the control device or with which the attribute list 15
is to be newly read-in or with which a new trigger event
30   may be determined. With the aid of the defined trigger
events and the attribute list 15 the read bus messages
are monitored and analyzed.

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In case a previously defined event occurs, the program
part "Acknowledgment" stops the cyclical overwriting of
the volatile storing medium 11 and its memory content is
5   transferred to the non-volatile storing medium 12.
Thereafter an SMS is prepared, by means of which an
external, preset calling address is informed over the
modem interface 10 that an event to be monitored occurred
and that in response to further query by the external
10   data processing device 14 the data may be read out, also
over the modem interface, from the non-volatile storing
medium 12.

The last program part "Terminate" serves for an orderly
15   shutdown of the transfer apparatus 7. The orderly
shutdown serves particularly for securing any attributes
and trigger events newly read into a non-volatile storing
medium for ensuring that at a subsequent start of the
motor vehicle they are again made available during
20   initialization of the executable program.

The most frequently utilized data bus system in motor
vehicles is the so-called CAN bus protocol. Therefore,
the structure of a message in a CAN bus system will be
25   briefly discussed in conjunction with Figure 3. CAN bus
systems are so-called non-deterministic bus systems. This
means that messages on these bus systems are not directly
assigned to the addresses of the control devices, but the
message itself is characterized based on a CAN
30   identifier, and the connected control devices decide,
based on an identifier list, which messages on the bus
should be read. Besides the CAN identifier, a CAN bus

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message, as a standard, contains 8 bytes with 0 - 7 useful data. Into which byte which useful data are inputted, depends to a large measure from the application programmer. Thus, for example, into byte 0 characteristic data concerning system recognition may be inputted. These may be particularly CAN data which characterize a specific control device in the network. Frequently error information is inputted into the byte 1. Such error information may be inputted as error codes, or merely individual bits from the byte, for example, the bits 0 - 3 may indicate an error by changing their value from a logic 0 to a logic 1. In the other bytes system data may be exchanged on the bus, particularly travel data in motor vehicle applications. In the concrete application example of Figure 1, these travel data are used for operating an automatically driven, driverless transport system. The core of the driverless transport system is an integrated power train which consists of the electronically controllable standard components: engine and transmission. To this are added a steer-by-wire steering and a brake-by-wire braking system. Since each of these X-by-wire systems can be controlled by purely electronic commands, their combination results in a complete, electronically controllable power train which is monitored and controlled by a unitary bus (CAN bus). Such a power train is expanded by coordinating electronics: the power train controller PTC. The travel data to be exchanged over the CAN bus pertain particularly to data for brake actuation, steering actuation, the set transmission stage, the vehicle position and the vehicle speed. A bus communication of this kind may be examined according to the invention by

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the transfer apparatus 7 concerning various attributes. On the one hand, the identifier, the so-called CAN identifier, may be utilized as a trigger event or as an attribute to be monitored. On the other hand, the data

5   for system recognition may be used for monitoring or the measures for an error characterization may be used for a monitoring process and for the initialization of a data logging into the non-volatile memory 12. The monitoring itself of the travel data may be utilized as a deciding

10   criterion for the definition of a trigger event. It may be, for example, monitored whether a permissible maximum speed has been exceeded, whether in case of a braking process all the brakes are actuated, whether in case of an applied reverse gear the travel program for reverse

15   travel is also activated, etc.

As already noted at the beginning, if for no other reason than for purposes of approval, the control devices in automated vehicles are, as a rule, redundantly designed.

20   The fall-back plane of the control devices then preferably also has a second, independent CAN bus as a communications network. In such a communications network with two CAN buses the transfer apparatus 7 is to be expanded by a second CAN interface. In such a case then

25   both CAN buses are read parallel.

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